

Radiation Hardened Technologies

The Nerve Center for BMD Sensors and Systems

To carry out their mission, Ballistic Missile Defense sensors and interceptors — as well as other battlefield weapons and space systems — must function reliably in any environment, particularly the alien environment of space and the hostile environment of the battlefield.

In space, radiation from the sun alone can degrade microelectronic circuits and optical components. Nuclear or conventional weapon-induced effects on the battlefield pose a direct threat to weapon system operation. Either environment poses a challenge for the space or weapons system developer. In addition, optical, electro-optical components and related electronics have the added stress of operating in a cryogenic environment.

Today, advanced sensors rely more heavily than ever on computer control and guidance combined with sophisticated infrared (IR) and optical systems. Hardened microelectronics that must not only survive but must continue to function even under highly adverse conditions are crucial to mission success. This trend toward reliance on ever more complex and capable electronics and IR/VIS components will continue to drive “hardening” initiatives.

An important role of the Systems Directorate’s Systems Engineering Division is to help space and weapon system developers achieve a balance between anticipated operational environments and integrated circuit/component performance goals. For example, where weight is a driving factor, significant microelectronic shielding may not be practical. In such cases, electronics optics and electro-optics built to tolerate higher dose rates inherently mean less shielding weight for a system.

As a working member of the DoD Radiation Hardened Oversight Council (RHOC) and working with commercial sector manufacturers, government laboratories, and other government agencies, the U.S. Army Space and Missile Defense Command’s (SMDC) High Performance Microelectronics program has developed key methodologies to ensure the availability of state-of-the-art hardened linear, digital, and nonvolatile electronics. In addition to SMDC’s pioneering work on hardening infrared detectors and readout circuits, the current Hardened Infrared Optical Cryo-component program has laid the foundation for understanding the physical processes of radiation effects in thin film interference filters as well as providing an extensive data base of effects observed in current state of the art optical components in long-wave infrared (LWIR) sensor/seeker systems.

Linear Electronics

The Space and Missile Defense Technical Center (SMDTC) is currently developing:

- High Resolution Analog/Digital Converters
- Ultra-Low Power Analog/Digital Converters

Nonvolatile Memory

The SMDTC has pursued a number of technology efforts to provide BMD systems with a wide range of performance options, including:

- Hardened Electrically Erasable Programmable Read Only Memory
- Magnetoresistive Random Access Memory
- Ferroelectric RAM

Rad Hard Optics/Electro-Optics

SMDC continues to pursue development of high performance optical components for LWIR seeker/sensor systems for both tactical and strategic mission requirements including:

- Thin Film Interference Filters
- Mirrors
- Windows
- Coatings
- IR FPAs

Test and Verification

The Radiation Hardened Technologies program has devoted considerable effort to evaluate electronics and optics technology as it becomes available. Test objectives include evaluation (to determine effects) and verification and validation (to demonstrate hardening). It is required that the test subjects be exercised under actual operating conditions while enduring radiation exposure. The test effort has assessed performance of optical, electro-optical, and electronic components in several radiation environments:

- Total Ionizing Dose
- Transient Dose (Upset/Survivability)
- Single Event Effects (Upset/Latchup/Burn-out)
- Neutrons (Upset and Damage)
- Protons

Radiation Effects on Electronics Multiple Environments = Multiple Effects

Environment	W	NS	W	W	W-NS	NS	W
	Neutrons	Protons Deuterons Tritons	Prompt Gammas & Hard X-Ray	Soft X-Rays	Gammas, Electrons	Heavy Ions	Electro- Magnetic Pulse
First Order Effect	Displacement Damage, Neutron Induced Upset	Displacement Damage, Ionization, Trapped Charge	Transient Photo- Currents	Energy Deposition	Trapped Charge	Localized Current Transient	Ionization Current, Voltage Transient
Result	Degraded Circuit Performance	Degraded Circuit Performance, Circuit Upset	Circuit Upset, Circuit Burnout (Dose Rate Upset/ Survivability)	Thermo- Mechanical Shock (TMS) Melting	Decreased Leakage Current, Circuit Failure (Total Dose)	Random Single Bit Upsets (SEU)	Circuit Upset, Circuit Burnout

Legend: **W** Weapon Induced **NS** Natural Space Induced

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